

ANTI-SUBMARINING SEAT-BELT ASSEMBLY

CROSS REFERENCE TO RELATED APPLICATIONS

5 This is an application of US-serial number 10/690,742 related to a division of an international application number PCT/DE98/03270 (WO 99/24294, European Patent EP 1 037 773 B1, German Patent DE 197 49 780 C2, Canadian Patent CA 2,313,780) filed Nov. 10, 1998.

BACKGROUND OF THE INVENTION

1. Field of the Invention:

10 It is an object of the present invention to prevent a restrained passenger of a transport system (motor vehicle, ship, train or aeroplane) from submarining, absorb impact energy of the passenger and dampen vibration in the event of any accident (front-, side-, rear-end collision and/or rollover or pile up/mass collision) or during in-flight turbulence.

2. Discussion of the Prior Art:

15 It is known in the prior art to provide for a passenger of a transport system an anti-submarining device in order to prevent severe/fatal injury in a rear-end collision.

In order to formulate in single terminology a generalized definition is presented for the proper term:

20

Definition:

"Stiff first transport-system member"

"Stiff second transport-system member"

"Seat frame"

Proper Term:

Floor 6 of the transport system adjacent to a first seat-side SR (Fig. 1) or seat-cushion frame at the first seat-side or mid-tunnel (not drawn) of the motor vehicle adjacent to the first seat-side.

Floor 6 of the transport system adjacent to a second seat-side SL or seat-cushion frame at the second seat-side or post section (not drawn) of the motor vehicle adjacent to the second seat-side or side rail of the motor vehicle adjacent to the second seat-side

Seat-cushion frame or seat-backrest frame

In order to prevent whiplash front seats of SAAB 9-5 cars are equipped with active head restraints (rests) that, each activated by the mass inertia force of the upper part of the body (torso) in rear-end collisions, move up and closer to head of the front-seated occupant. See shortcomings, undermentioned.

In collaboration with Autoliv Corp., the biggest car-supplier in the world, Volvo Corp. has developed WHIPS (Whiplash Injury Prevention System), installed in the front seats of Volvo S80s. Under load of mass inertia forces of a passenger's torso in a rear-end collision the hinge of the seat backrest yields and partially rotates backwards and downwards to facilitate the head rest to intercept the head and the seat backrest, filled with pads, to absorb forces. When a car crashes into the rear section of a Volvo S80 and both catch fire, the front-seated passengers and their seat backrests, rotated backwards and downwards, impede the evacuation of the back-seated passengers, who may be severely injured. The front-seated passengers must sit up in order to take further action. Taken as given, the rotated seat backrests cannot be returned to the home position precious time elapses to step out of the car. This raises the question of how the front-seated, back-seated passengers and/or back-seated children, exposed to explosion, burn and/or toxic smoke, can evacuate themselves out of Volvo S80 and V70, both catching fire while travelling on roads, and/or how rescue workers can evacuate all the severely injured back-seated passengers.

Due to lack of space, in which the SAAB and Volvo protective devices should be installed, heads of back-seated passengers are unprotected, hence, subjected to whiplash and severe/fatal injury resulting from submarining. For sure, both protective devices remain ineffective in a multi-crash when the front-seated passengers, being submarining underneath their respective lap belt portions, is crushed into death by the airbags, deployed in the front-end crash or falsely deployed in the rear-end crash.

Exemplified in DE 43 36 351 A1, a pan, moveable along a pair of rails beneath the seat cushion, is activated in a rear-end collision and moved out therefrom to intercept a passenger when submarining and falling down therefrom. Ref. to EP 0 403 072 A2 a pair of U-shaped ramps is built in a rear seat. Each ramp comprises two longitudinal members, both fastened to the vehicle floor, and a lateral member, which, arranged along the front portion of the rear seat, intercepts a submarining passenger in a rear-end collision.

Both anti-submarining devices can never prevent severe/fatal injuries linked to great belt force, deployed or falsely deployed airbags, different weights and/or different body proportions.

5 When a Ford Mondeo, swerving on a road outside the city Idstein, crashes twice into a barrier and finally into a bus, the face of an obese female driver, submarining, is fractured and crushed by the airbag into her skull. In the real-world multi-front-end collision at far higher speed and strong yaw-acceleration great rotatory- and longitudinal-acceleration dependant forces (Figs. 4, 5) enormously elongate the lap belt portion underneath which the belted passenger submarines in the direction „ L_y “ or „ Z_E “ (Figs. 4 and 7) due to the limitation of
10 the belt pretensioner which can only retract the seat belt up to 30 cm. All the anti-submarining devices, above-mentioned, can never prevent obese passengers from submarining when their car is involved in a real-world multi-front-end collision.

Any belted passenger, lying in a sleeping position ref. to DE 37 41 831 C2 (Fig. 7), submarines when being loaded by great mass inertia force „ S_y “ in the direction „ Z_E “ in the
15 event of accident.

US 3,977,696 discloses a four-point seat belt, comprising a three-point seat belt and an upper shoulder belt, both of which, provided with belt retractors, are guided in two rails and driven by electrical motors of a heavy device. When the vehicle roof is totally deformed in a rollover-accident the heavy device crushes the passengers into death.

20 US 5,123,673 discloses a four-point seat belt, comprising a three-point seat belt and an upper shoulder belt, both of which are provided with belt retractors. An intricate, automatic release device facilitates the release of both buckle assemblies, each equipped with an actuator to release them, regardless of which one is manually released first. When an MB 200 crashes into the vehicle door of an MB S in the city of Geisenheim, a lateral intrusion of
25 about 80 cm is measured.

When used, the buckle assembly, actuator and other parts, all of which face the totally deformed vehicle door, are destroyed. Hence, the other one does not function. The severely injured driver remains restrained. Rescue workers can't evacuate him within seconds.

In the NHSTA side crash test, which, currently legislated, idealizes an SUV crashing at an
30 angle of 30° into a door or vehicle side. As a result, the buckle assembly, actuator and other parts are destroyed.

A complicated latch-plate-feeding device, installed to the side of seat cushion, moves forwards to present the latch plate of the three-point seat belt to the passenger, after having sat down. This device, facing the vehicle door totally deformed in a side crash, is destroyed.

US 5,641,200 discloses a child restraint seat for securing a child in a shopping cart, provided with a seat cushion and backrest on which the child is seated. A pair of shoulder belts, fastened at the mid portions to the seat backrest, has two pairs of end portions which, equipped with a pair of belt connectors, consisting of tabs and receptacles, extend across in an X-shape over the child, being restrained when the tabs are inserted into the respective receptacles.

10 Harness restraint systems ref. to US 4,231,616, US 4,402,548, US 5,131,683, US 5,524,928, US 6,139,111, US 6,179,329 B1 and US 6,705,641 B2 are well-known as suspender belts. Each belt portion of the suspender belt or each belt must always be adjusted to an appropriate length depending on the size of the passenger as well as on what he is wearing. All these suspender belts have the following drawbacks:

15 **D1.** In general, suspender belts are not popular because finding all the belt portions and connecting all the attachment ends to the release device is a lengthy process, especially in the dark. Moreover, all the belt portions make an untidy impression and are not beneficial for sales.

20 **D2.** Exemplified in US 6,139,111, all four belts are retracted to different lengths and blocked by the four respective pretension retractors within different time frames in milliseconds in an accident. It doesn't work. Each five-person car additionally needs 15 pretension retractors. No car corporation will waste money for additional pretension retractors installed in millions of motor vehicles produced annually.

25 **D3.** Under the load of the same belt force in a front collision the deformation of the seat backrest, wherein both belt ends are fastened, is larger, thus increasing the forward motion.

30 **D4.** The biggest drawback is the failure of the restraint. When the belt force exceeds 24,000 N due to lack of energy absorbers in real-world accidents the passengers are severely/fatally injured. Moreover, the restraint fails because the belt elongates at a force-dependant rate over 25 %, shown in Fig. 6 of PCT/US99/13362. A belted heavy driver of AUDI A6 freed himself out of the restraint in a rollover accident.

Despite being properly restrained and properly seated on a child-seat, perfectly secured to the rear seat, a six-year old child, freeing himself out of the restraint, was ejected out of a Toyota Yaris, travelling at 100 km/h, when laterally slamming into a concrete wall.

Ref. to Figs. 8 and 9 of US 5,524,928 the harness restraint system is defined by

- 5 a) two shoulder belts 12, 14, each equipped with a belt retractor 20 (see **D2**),
- b) a pair of lap belts 46, fastened to the vehicle floor and equipped with eyelets 44 loosely connected to both shoulder belts, and
- c) a Y-shaped connector 26, comprising
 - a first web 26a fastened to the shoulder belt 14,
 - 10 ▪ a second web 26b, serving as a buckle assembly having a release button 34 to be plug-in connected to a latch plate 32b (not drawn) of shoulder belt 12, and
 - a third web 26c, serving as a buckle assembly having a release button 28 to be plug-in connected to a latch plate 32c (not drawn), fastened to one end of an anti-submarining belt 24, projected through a sleeve 50 of the seat 16 and the other end of
 - 15 which is fastened to the vehicle floor.

This restraint system, characterized by the drawbacks **D1 to D4**, has the following drawbacks:

D5. When the lap belts 46 with fixed length are laid out for, say, skinny, 1.5 metre tall Asians, obese, over 2 metre tall passengers cannot use the restraint systems at all. Due to

20 the failure of the principle feature to protect various sizes of the passengers from submarining no agencies world-wide give approval to motor vehicles, equipped therewith, thus resulting in bankruptcy of the car corp.

D6. Because all three belts 24, 46 have fixed lengths the seat can neither be moved in any direction, particularly in the furthest forward or rearward position, nor be tilted in

25 different sloping seat-positions nor can the passenger remain restrained in any seat-position. Due to the failure of the principle feature to co-operate with seat-adjusting mechanisms nobody buys motor vehicles, equipped therewith, thus resulting in bankruptcy of the car corp.

D7. Given, all five belts are equipped with belt retractors and pretensioners, skinny and

30 normal passengers 18A, 18 would be „protected” against submarining when the latch plate 32c is plug-in connected to the third web 26c. For sure, passengers 18A, 18, restrained in slack mode, under great submarining force „ S_y ” (**Fig. 7**) are forced into the

stiff, Y-shaped connectors 26 and are severely/fatally injured or castrated, if they are male! In addition thereto, the respective airbags crush the heads of the passengers, while submarining, into the seat backrests. Compensatory damages of millions of dollars are due.

5 **D8.** Crotch pads 160, designed to absorb submarining energy and each placed in between the crotch and the hole of sleeve 50, in different sizes must be designed for passengers from skinny to obese size! Putting them into use consumes time.

D9. When an obese passenger 18B takes his seat, he, covering the hole of sleeve 50, can never be restrained to prevent submarining. Hence, this feature discriminates against 51
10 million obese US-adults, 30 million obese Chinese children and millions of obese Asians, Europeans and Canadians!

D10. The belt user has to depress two release buttons 34, 28 to release the respective latch plates from the buckle assemblies 26b, 26c. This two-click operation causes discomfort and hinders rescue work. See one-click operation by depressing the master release
15 button, mentioned below.

D11. Ford Corp. has recalled 1.4 million brand-new motor vehicles due to the unreliability of the plug-in connection of latch plate with buckle assembly, both of which are standard parts manufactured by the renown supplier TRW! The latch plate, when inserted into the buckle assembly and connected thereto, can be detached therefrom during normal use.

20 Y-shaped connectors 26 and energy-absorbing crotch pads 160 have to undergo lengthy, expensive testing and certification for reliability during normal use and in real-world accidents.

D12. The space underneath of the seat cushion 3.1, 3.1B of front or rear seat 3, 3B of a motor vehicle is exploited for a storage bin 15, 15B (Figs. 8 to 11) which, defined by
25 three fixed side walls 15.1a, 15.2, 15.3, a front- or side opening door 15.4a, 15.4B, 15.4aB, a bottom bin-floor 15.6 and the seat cushion itself 3.1, 3.1B, is patented by the inventor and found in VW-, Renault- and Opel vans. Due to the anti-submarining belt 24 eliminating the space for the storage bin, engineers of those car corporations must redesign vans without storage bins if this invention is put into use.

30 Of course, car corporations world-wide have no intention of taking the risk of going bankrupt resulting from lack of agencies' approval of cars, equipped with such harness restraint systems, the drawbacks **D1 to D12**, pouring billions of dollars into the tests,

redesigning, recall actions, 20 additional belt retractors and pretensioners per five-person car, lawsuits and compensatory damages linked to severe/fatal injuries. Doubtless, only the features, listed herein, in co-operation with vibration-dampening energy absorbers are capable of resolving all these problems and others and the advantages thereof are obvious!

5 Ref. to US 4,231,616 a harness restraint system comprises a pair of belt deflectors, loosely connected to a pair of side attachment points at the seat-sides, an upper attachment point, located over the head, and a pair of length-adjustable belts, fastened together to the upper attachment point, projected through the belt deflectors and provided with a latch plate and buckle assembly at the respective distal ends.

10 Ref. to US 4,402,548 a safety seat comprises a shell-shaped seat, consisting of

a) a seat backrest, having

- a pair of lateral head-supporting pads,
- a pair of side portions and
- several pairs of anchorage slots on the back portion,

15 b) a seat cushion and

c) a harness restraint system, having

- a pair of length-adjustable shoulder belts, projected through the anchorage slots and fastened to attachment points at the side portions,
- a pair of length-adjustable lap belts, projected through a pair of anchorage slots and fastened to junctions between the pair of side portions and the seat cushion,
- 20 ▪ an anti-submarining belt, projected through an anchorage slot of the seat cushion and fastened to the seat cushion, and
- a centrally positioned three-point release device, by which all five belts are interconnected.

25 Ref. to US 5,131,683 a harness restraint system comprises

a) a Y-shaped belt, consisting of a pair of shoulder belt portions, looping over the seat backrest and provided with two belt retractors fastened to the vehicle floor,

b) an abdomen belt portion, provided with a webbing ring,

c) a right lap belt, one end of which is fastened to the seat and the other, equipped with a

30 latch plate, projecting through the webbing ring, and

d) a left lap belt, one end of which fastened to the seat and the other, equipped with a buckle assembly.

To buckle up an actress pulls the latch plate, positioned to the headrest, over her shoulder and the Y-shaped belt, damaging her hat and hair-style, over the upper part of her body. She misses the film festival.

Ref. to US 6,139,111 a harness restraint system comprises

- a) a pair of shoulder belts, projecting through a head rest and connected to load-limiting belt retractors mounted on a cross member of the seat backrest,
- b) a pair of leg belts, connected to pretension retractors mounted on a pair of seat rails,
- 10 c) a buckle assembly, to which the shoulder belt and lap belt are coupled, and
- d) a latch plate, to which the other shoulder belt and lap belt are coupled.

Ref. to US 6,179,329 B1 a harness restraint system comprises a pair of length-adjustable shoulder belts, a neck belt, a pair of length-adjustable lap belts, an anti-submarining, length-adjustable belt and a conventional five-point release device, to which all the belts are
15 connected. The manufacturing of each length-adjustable shoulder belt, defined by a lower and upper vertical belt, an abdomen- and a shoulder belt adjuster and other parts, is very intricate. The harness is attached to the seat at four attachment points. The top portions of shoulder belts, the neck belt and a neck strap cover are sewn together into a neck unit attached to the top attachment point by a neck belt component. The belted passenger is crippled under great
20 yaw load due to the rupture of the neck belt component and the single top attachment point, incapable of sustaining the yaw load.

Ref. to US 6,705,641 B2 an inflatable harness restraint system comprises

- a) a pair of inflatable shoulder belts, filled with inflatable members, such as gas or gas pellets, and extending over the upper part of the body of a passenger,
- 25 b) a pair of inflatable leg belts, filled with inflatable members, provided with belt retractors and restraining the lower part of the body,
- c) a pair of anti-submarining belts, restraining the legs,
- d) a buckle assembly, to which the inflatable shoulder belt, inflatable lap belt and anti-submarining belt are coupled, and
- 30 e) a latch plate, to which the other inflatable shoulder belt, inflatable lap belt and anti-submarining belt are coupled.

The explosion of one front airbag of VW Golf IV, reported by the television program "Plusminus" of German Broadcasting Station ARD on Sept. 21, 98, was measured at over 167 dB, exceeding the EU's threshold value of 140 dB, thus resulting in hearing damage or deafening. Dr. Beat W. Hohmann from Suva, a Swiss Accident Insurer in Lucerne,
5 accomplished this test and a research work, in which the results, based on the theories, are validated by the test data.

Due to the burning of faces and/or hands by hot gases leaking from the airbags, a US-court imposed a fine of \$ 123.6 millions on Daimler Chrysler. In a front collision in Rotterdam a female driver of Volvo suffered face-burns of first and second degree. When a VW bus
10 collided into the left front fender of a 6-day old, € 98,000 expensive MB SL 500, both at 30 km/h cruising speed in the city Geisenheim according to the MB driver, the airbags inflicted burns of first to third degree on the MB driver and co-driver and the seat belt squeezed the bosom of the MB co-driver.

If this inflatable harness restraint system, when inflated, inflicts deafening, injury and/or burns
15 of first to third degree on an American, compensatory damages of three-figure millions of dollars are due.

In view of foregoing shortcomings, injuries and deficiencies, there is a need to ensure the restraint of any passenger as well as the operation of the anti-submarining devices in any accident.

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SUMMARY OF THE INVENTION

Accordingly, the principle object of the present invention is to provide for passengers of a transport system anti-submarining seat-belt assemblies which resolve all the above-mentioned shortcomings and deficiencies, prevent submarining and injuries, absorb impact energy and dampen vibration in the event of an accident or during in-flight turbulence and are suited for two-, three- and multi-point seat belts.

A second object of the present invention resides in one-click operation by means of a master release button, when depressed, to release the main and anti-submarining latch plates from the respective buckle assemblies. In emergency cases paramedics and fire-fighters can easily rescue the injured passengers.

A third object of the present invention resides in a cost-, space-saving integration of a multi-point seat belt, equipped with vibration-dampening energy absorbers, the anti-submarining seat-belt assembly and the seat into a safety seat, which can be converted into a baby-cot, child-seat or adult seat and vice-versa, illustrated in Figs. 1, 5.

INDUSTRIAL APPLICABILITY

It should be apparent that the invention provides substantially improved restraint including the following features:

- a) The survival chance is enhanced by the restraint of
 - * both shoulders and the torso, when the passenger is thrown forward (Table 3) and/or subjected to the yaw \ddot{O} -acceleration-dependent torque „ T_{δ} ”, and
 - * both thighs and the lower part of the body, when the passenger submarines.
- b) A number of sets of vibration-dampening energy absorbers ref. to US serial no. 09/554,464 (WO 99/24292, PCT/DE98/03271, European Patent EP 1 037 771 B1, German Patent DE 197 58 498 C2 and CA pending patent 2,314,345) or German Patent DE 197 58 497 C2 can be attached to coupling fittings of anti-submarining seat belt assemblies (Figs. 3a, 3b, 3c). Hence, large impact energy can be gradually absorbed below the respective injury-related values. Several sets of vibration-dampening energy absorbers can be attached to a length-adjustable belt of the anti-submarining seat belt assembly 8b, 8c (Fig. 1). The inventor of the present application has submitted those patent documents and applications to CIPO as well as USPTO. The vibration-dampening energy absorber

consists of a number of clamping elements, having sites of predetermined fracture, and a retaining element, which, fastened to the seat backrest frame and/or seat frame, can serve as an integral part thereof. When the clamping elements, biased on the retaining element, under great belt force move therealong vibration is dampened by friction.

- 5 c) Owing to the different positions of anti-submarining buckle assemblies, in plug-in connection with the respective anti-submarining latch plates, passengers of different body proportions, thighs and weight can adjust the length of the anti-submarining belt portions **1.3R, 1.3L** by themselves. Moreover, the adult seats, equipped therewith, can be modified for children and vice versa, thus increasing the rate of seat occupancy in a bus, train or an
- 10 aeroplane, exemplified in **Fig. 5**. In another embodiment the length-adjustable belt of the anti-submarining seat belt assembly **8b, 8c** facilitates, for example, a female passenger to adapt the belt length to her long gown or to herself, when lying in sleeping position (**Figs. 1, 7**).
- d) For safety reasons and easy access the anti-submarining latch plates **11, 25**, when not
- 15 being used, are stored in a storage box **25.5** (**Fig. 5**). The belt-detachable anti-submarining latch plates **25** (**Fig. 2**) are attached to the lap belt portion when needed.
- e) For the convenience of the passenger, when stepping out, or for a fast rescue of the passenger injured in an accident, the master release button **84** of the buckle assembly **9.1** is depressed to release all latch plates from the buckle assemblies.

BRIEF DESCRIPTION OF THE DRAWINGS

A number of embodiments, other advantages and features of the present invention will be described in the accompanying tables and drawings with reference to the xyz global coordinate system:

25 **Table 1** shows test data such as left / right thigh-force, belt force and pitch-angle of driver and co-driver in 50% offset crash test of several European vehicles at crash speed of 55 km/h.

Table 2 shows yaw angle θ of driver / co-driver in a 50% offset crash tests.

Table 3 shows test data of the safest child-restraint system Chico Shuttle® at the converted

30 velocity of 55 km/h in comparison with the safest vehicle among them listed in **Table 1**.

Fig. 1 is a perspective view of a seat with upper buckle assemblies and anti-submarining buckle assemblies **7, 8, 8a to 8d**, attached to the seat backrest and seat cushion, as well

as of a restraint system consisting of a multi-point seat belt **1**, latch plate **11** along the lap belt, shoulder latch plate **2** of belt end, in the direction of arrow „Z” in plug-in connection with an upper buckle assembly **4**, and a seat belt in X-shape, formed by crossing both shoulder belt portions **1.1**, **1.2**.

5 **Fig. 2** is a schematic view of a detachable anti-submarining latch plate **25**.

Fig. 3a is a schematic, perspective view of a 1st embodiment of a buckle assembly **4a**, equipped with a release cable **4.2**.

Fig. 3b is a schematic, perspective view of a 2nd embodiment of a buckle assembly **4b**, equipped with an electrical release-motor **4.2b**.

10 **Fig. 3c** is a schematic, perspective view of a 3rd embodiment of a buckle assembly **4c**, equipped with a release cable **4.3**.

Fig. 4 is a perspective view of a anti-submarining latch plate **11** of a lap belt portion **1.3** in plug-in connection with the anti-submarining buckle assembly **8**.

15 **Fig. 5** is a front view of the seat **3a to 3d**, in which the restraint systems **1a to 1d**, anti-submarining seat-belt assemblies and storage boxes **25.5** are integrated, for passengers of different weights, different circumference of thighs and different body proportions (sizes), where anti-submarining buckle assemblies are in plug-in connection with the anti-submarining latch plates **11**, **25**.

20 **Fig. 6** illustrates two curves of strain/elongation rate dependent from force ref. to PCT/US99/13362.

Fig. 7 is a top view of a \angle - shaped seat belt ref. to DE 37 41 831 A1, where a belted passenger, in sleeping position, under load of great mass inertia force „S_y“ in the direction „Z_E“ submerges.

25 **Fig. 8** is a front view of a fixed seat equipped with a harness restraint system ref. to US 5,524,928.

Fig. 9 is a side view of the fixed seat equipped with the harness restraint system ref. to US 5,524,928.

Fig. 10 is a perspective view of a seat, moveable along a pair of floor rail assemblies equipped with a storage bin **15** ref. to DE 196 55 051 C2.

30 **Fig. 11** is a perspective view of a fixed seat equipped with another storage bin **15B** ref. to DE 196 55 051 C2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The advantages of the preferred embodiments in the Chap. "INDUSTRIAL APPLICABILITY" are outlined hereinafter with regard to the functions and features thereof.

- 5 Just at a crash speed of 55 km/h the belt force of a driver of the premium car AUDI A8 is measured 9,130 N (**Table 1**) equivalent to 2,015 pound by which the seat belt is elongated (strained) about 19 % (**Fig. 6**). The elongation ranges from 47.5 to 57 cm when the seat belt is 2.5 to 3 m long. In case the belt pretensioner remains inoperative and, in particular, the total mass inertia force „ S_y “ of the lower part of the body of the passenger is far larger than
- 10 that of the upper part thereof his body slips (submarines) underneath the lap belt portion in a real-world accident. The method of the present invention capitalizes on the premise that a lap belt portion, restraining a lower part of the body of the belted passenger, is subdivided into two anti-submarining belt portions **1.3R**, **1.3L** which properly restrain as well as hold his thighs when plug-in connecting at least one anti-submarining latch plate **11**, **25** to the
- 15 respective one of anti-submarining buckle assemblies **7**, **8**, **8a** to **8d** (**Figs. 1**, **4** and **5**), all of which are equipped with vibration-dampening energy absorbers. As a result, the anti-submarining seat-belt assembly in association with vibration-dampening energy absorbers
- substantially lowers large belt force, for example, of 15,190 N at only 55 km/h (**Table 1**), in a real-world accident or during in-flight turbulence,
 - 20 – prevents large elongation of the seat belt webbing, severe/fatal injury and the passenger of a Mercedes Car, lying in the sleeping position (**Fig. 7**), from submarining and
 - ensures the operation of the active head restraint of SAAB 9-5 and
 - resolves all the drawbacks of Volvo's WHIPS and the prior art.

In an embodiment the release button **84f**, **84e** of free-moving anti-submarining buckle assembly **8b**, **8c** (**Fig. 1**), whose housing is free-moving on the seat cushion and whose length-adjustable belt is fastened to the seat frame, can be controlled neither by a release cable **4.2** nor by an electrical release-motor **4.2b**. Hence, the release button **84e**, **84f** can only be activated by an electrical signal emitted from the master release button **84**, when depressed, to remove the protection from submarining.

30 Because the reel (spool) of the conventional belt retractor can accommodate only a limited length of belt, it is possible that the length of the seat belt for the sleeping position is

insufficient. The length-adjustable belt compensates for the length of seat belt **1** and accommodates the passenger, particularly when being obese, in all positions between the sleeping and normal position.

5 An anti-submarining buckle assembly **8d**, provided with a release button **84d**, is attached to the front portion of the seat cushion. This feature facilitates the obese passenger or a lady in a gown to restrain the thighs by plug-in connecting the anti-submarining latch plate **11** thereto.

Due to the plug-in connection of the anti-submarining latch plates **11**, **25** with the anti-submarining buckle assemblies a lady in a long gown as well as a child are well protected from submarining. The anti-submarining belt portions, restraining a child's or baby's thighs with small circumference, are secured to the seat cushion by the latch plate **11**, plug-in
10 connected to one of the anti-submarining buckle assemblies **8**, **8a** to **8d**, and the detachable anti-submarining latch plates **25**, plug-in connected to at least one pair of anti-submarining buckle assemblies **7** (**Figs. 1, 5**). For safety reasons and easy access the anti-submarining latch plates, when not being used, are stored and secured in a storage box **25.5** of the seat
15 (**Fig. 5**).

In the 1st, 2nd and 3rd embodiment (**Figs. 3a to 3c**) the buckle assembly **4a**, **4b**, **4c** is form-and/or force-locking connected to the seat-backrest frame. For the convenience of the passenger when egressing from the vehicle and in cases of emergency the following embodiments of detachment are proposed:

20 To disconnect the latch plates **2**, **11** and/or **25** from the upper buckle assemblies **4**, **18**, **18a**, **18b**, **18.1** to **18.3**, **19**, **19a**, **19b**, **19.1** to **19.3** (**Figs. 1** and **5**) of the seat arrangement, particularly in the case of children, as well as from the anti-submarining buckle assemblies **7**, **8**, **8a** to **8d** (**Figs. 1, 4**), the master release button **84**, when depressed, activates the release cables **4.2** and/or electrical release-motors **4.2b**, which pull the release button **84a** and/or **84b**
25 of all the buckle assemblies (**Figs. 3a, 3b, 3c**).

By law passengers travelling in a motor vehicle or experiencing flight-turbulence must remain belted. The need for a belted mother to turn around becomes apparent, when she must attend to her children sitting on the rear seat. The separately operated release buttons **84o**, **84d**, **84e**, **84f**, when depressed, detach only the anti-submarining latch plates **11**, **25** of
30 the lap belt portions from the assemblies **7**, **8**, **8a** to **8d** (**Figs. 1, 4** and **5**) to free the mother and/or children from the anti-submarining protection while the mother and/or children remain

belted. The anti-submarining buckle assemblies **7, 8, 8a**, whose housings are located in the seat cushion **3.1, 3.1a to 3.1d**, have the common release button **84o** on the seat.

In order to ensure the survival chance engineers must take care of the limitation of energy absorption depending on the permissible elongation of the anti-submarining belt portions

5 **1.3R, 1.3L** and/or the length-adjustable belt **8.1**. Tests can determine that permissible elongation up to which the anti-submarining seat-belt assembly in co-operation with the energy-absorbing seat belt **1** and/or the energy-absorbing length-adjustable belt **8.1**, attached to the seat frame, always ensures the survival chance of the belted passenger in any accident. In order to absorb great energy and dampen strong vibration vibration-dampening energy
10 absorbers must be put into use.

Although the present invention has been described and illustrated in detail, it is clearly understood that the terminology used is intended to describe rather than limit. Many more objects, embodiments, features and variations of the present invention are possible in light of the above-mentioned teachings. Therefore, within the spirit and scope of the appended
15 claims, the present invention may be practised otherwise than as specifically described and illustrated.